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COVID-19 DETECTION USING DEEP LEARNING WITH TRANSFER LEARNING

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ABSTRACT

The COVID-19 pandemic took many lives worldwide because of its fast-spreading nature, fast and accurate detection and diagnosis are very important. There are many types of COVID-19 tests, some are not accurate and some tests like Polymerase Chain Reaction (PCR) are accurate, but require more time, so detection of COVID-19 based on X-ray images of lungs is widely used. Several studies were conducted for the detection of COVID-19 based on X-ray images of lungs, most of the studies used state-of-the-art Convolution Neural Networks with transfer learning. These state-of-the-art CNN needs a huge amount of data to properly adjust a huge number of parameters. In this paper, we propose a simple CNN model which requires less data compared to the state-of-the-art CNN architectures and gives better results on the X-ray images of lungs. In this study proposed model achieved the best results compared to state-of-the-art CNN models on the X-ray images for the COVID-19 pneumonia patient dataset.

KEYWORDS: Deep Learning, Transfer Learning, Covid-19, Image Classification & CNN

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Original Article

INTRODUCTION

The novel coronavirus disease (COVID-19) is caused by highly contagious Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). Because COVID-19 highly infectious nature spread around the world rapidly, identification of COVID-19 as quickly as possible to reduce the spread.

Artificial Intelligence techniques widely adopted for medical research, mainly deep learning techniques achieved greater success in biomedical research, particularly Convolutional Neural Networks are widely used and prominent models for computer vision, medical image diagnosis, and speech recognition tasks. Modern CNN architectures proved that deep networks achieve good performance on complex problems such as natural language processing and computer vision.

CNN was introduced by Yann LeCun in 1989, this new technique was mainly used for solving computer vision problems. CNN will work on unstructured data very well compared to other machine learning techniques because of its special architecture. CNN is mainly composed of convolution and pooling layers they work very well for extracting features from unstructured data like images and video.

AlexNet is the first deep neural network to win the ImageNet Large Scale Visual Recognition Challenge(ILSVRC). Modern CNN architectures such as VGG, DenseNet, ResNet, GoogleNet, and MobileNet are created based on AlexNet.

Regularization is used to avoid overfitting problems in machine learning, there are various regularization techniques, the most popular techniques are weight decay, data augmentation, early stopping, dropout, and batch normalization. Dropout regularization technique randomly drops some percentage of nodes from the neural network by doing so which makes the neural network sparse which will help to avoid overfitting. Early stopping is a regularization technique that stops at the point where the performance of the training set increases, but the performance of the validation set starts to degrade. Data augmentation avoids overfitting generating synthetic data if more data provided for training models will perform better with unseen data.

RELATED WORKS

State-of-the-art CNN architectures were widely used for COVID-19 detection with transfer learning technique.

In Ref. [1] Amyar et al. propose a deep learning-based multi-task model to identify COVID-19 patients. The authors compared their proposed model with state-of-the-art CNN models and they achieved a classification accuracy of 95%.

In Ref. [4] authors used the dynamic CNN modification method for the classification of COVID-19 chest X-Ray and CT images, in that study authors modified the ResNet model and created modified CNN and they have done multiclass classification for three classes.

In Ref. [5] authors proposed a Deep Transfer Learning binary classification model based on DenseNet201 to identify COVID-19 patients and achieved an accuracy of 99.82%, 96.25%, and 97.4% for training, testing and validation respectively.

In Ref. [6] Apostolopoulos et al. Claimed that deep learning on X-ray images may extract significant biomarkers.

In Ref. [7] Ismael, A. M., & Şengür, A. proposed a deep learning model for COVID-19 detection authors have used ResNet50 for feature extraction and SVM with linear kernel for the classification achieved a 94.7% accuracy score.

Bhandary et al. used modified AlexNet for the detection of pneumonia. by using X-ray images. In Ref. [9] Wang et al. Designed COVID-Net for the detection of COVID-19 patients by using X-ray images, with COVID-Net authors achieved 90.5%, 91.3%, and 98.9% Positive Predictive Value for three infection types Normal, Non-COVID19, and COVID19 respectively.

In Ref. [10] Dongsheng Ji et al. Proposed a deep learning model based on feature fusion for COVID-19 detection by using X-ray image data.

Based on all of this literature, most of the authors used deep learning approaches mainly deep convolutional neural network architectures, state of the art CNN's achieved significant success in the detection of COVID19 by using X-ray image data.

Data Set

The data set used in this study X-ray images of COVID-19 pneumonia patients [2,3] contains four classes of images COVID-19 positive, normal, non-COVID lung infection, and Viral Pneumonia.

This dataset comprised of a total of 21,165 images3616 COVID-19 positive images where 3616 images are COVID-19 positive X-ray images, 6012 images are non-COVID lung infection X-ray images, 10192 images are normal X-ray

images and 1345 images are Viral Pneumonia X-ray images.

METHODOLOGY

In this study, we have done multiclass classification on X-ray images for COVID-19 pneumonia patients[2,3] dataset by applying the transfer learning technique. First, we have applied data pre-processing, then we have used pre-trained models for feature extraction after that we have used a fully connected layer for classification purposes.

Pre-Processing

Pre-processing is the first step in machine learning, it should be done carefully to get good results, in this study, we have used state of the art CNN models ResNet50, Inception_V3, Exception, VGG16, and Inception_ResNet_V2 for transfer learning, all of these state-of-the-art models are very complex models require huge amounts of data, but there are limited medical data available related COVID-19. Since CNN's accepts fixed-size input all the images were resized to 224x224 pixels.

Data Pre-Processing technique data augmentation is used to generate more synthetic data for the classification task in the feature extraction of all these state-of-the-art models trained on the ImageNet dataset, we have considered 70 % of the dataset for training and 30 % data for validation.

Transfer Learning with CNN

Transfer learning is a technique mainly used for saving time and computational resources, for solving complex problems with high-efficiency machine learning models require more resources and time for training.

In the initial state, CNN extracts features from images that are required to perform classification tasks, low-level features such as dots, edges, and simple shapes are similar for all images, this task will be performed by using the transfer learning technique. The extracted features will be passed to a fully connected layer for the classification task.

Simple CNN with Regularization and parameter tuning techniques

In this study, we created a simple CNN with a lesser number of parameters compared with the state-of-the-art CNNs with regularization techniques and parameter tuning. This model takes the 224x224x3 images, then BatchNormalization applied, stacked 3x3 convolution and max-pooling 3x3 with dropout layers after that Flatten layers, then two dense layers with 256 and 128 units with dropout, last dense layer with 4 units with softmax activation used for multiclass classification.

Adam optimizer was used for the compilation of models. All the models were trained for 20 epochs.

RESULTS AND DISCUSSION

This study uses VGG16, ResNet50, InceptionV3, VGG19, Xception, MobileNet, DenseNet121, and Simple CNN for multiclass classification of X-ray images for COVID-19 pneumonia patients data, all of these models were trained under the same conditions.

Table 1: Shows the Training Accuracy of all the Models used in This Study

Table 1: Accuracy for the Training Set and Test Set

Model	Test Accuracy	Train Accuracy
VGG16	87.24%	87.30%
ResNet50	75.53%	77.74%
InceptionV3	77.63%	76.89%
VGG19	88.91%	88.84%
Xception	74.05%	73.25%
MobileNet	83.76%	82.71%
DenseNet121	83.20%	85.01%
Simple CNN with regularization	94.74%	97.37%

We can observe that from the state of the art CNN models VGG19 achieved the highest accuracy 88.91%. SimpleCNN is the simple and lightweight Convolutional Neural Net compared to the state-of-the-art CNN models, which is also having very lesser parameters outperforms all state-of-the-art CNN models with 94.74% test accuracy for this multiclass classification of X-ray images for COVID-19 pneumonia patients data.

CONCLUSIONS

This study compared the state-of-the-art CNN models using transfer learning with a simple CNN model with a regularization approach and parameter tuning based on the observed results we can conclude the below conclusions.

- All these state-of-the-art CNN models used for COVID-19 detection by using transfer learning could not achieve the best performance even after using the data augmentation as they were achieved on the ImageNet dataset, this might be because of a limited number of COVID-19 X-ray image data.
- CNN model with regularization and parameter tuning having less number of parameters achieved better accuracy compared to state of the art CNN models for this multiclass classification on the X-ray images for COVID-19 pneumonia patients dataset[2,3].
- Compared to transfer learning with pre-trained models, small end-to-end trained models perform better with some fine-tuning.

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